NAVAL POSTGRADUATE SCHOOL
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THESIS

COST ESTIMATING METHODS UTILIZED BY THE
DEFENSE AEROSPACE INDUSTRY IN THE
PRODUCTION OF TECHNICAL DATA

by

Joseph Wilfred Lemire Jr.

June 1985

Thesis Advisor: D.V. Lamm

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Cost Estimating Methods Utilized by the Defense Aerospace Industry in the Production of Technical Data

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TABLE OF CONTENTS

I. INTRODUCTION

A. RESEARCH OBJECTIVE

Government purchase of technical data for competitive reprocurement is an issue that is currently in the forefront of the defense acquisition arena. Both legislative and regulatory initiatives have recently been drafted that require defense contractors to price their data and make it available for purchase by the Government. Yet within Government procurement circles, a methodology to determine what technical data should cost does not exist. Additionally, there is no established cost data base that permits the comparison and evaluation of technical data price proposals. To evaluate a proposed price for technical data, Government analysts should first understand what functions are performed in producing technical data, what the cost elements of those functions are, what environmental factors affect those elements, and what cost estimating methods are utilized. The purchase of this research was to determine what functions, cost elements, environmental factors, and estimating techniques are common to defense aerospace contractors in the production of technical data.

B. RESEARCH QUESTIONS

Given the preceding objective, the following primary research question was posed: What methods are used by the

defense aerospace industry to estimate the cost of technical data?

The following subsidiary research questions were considered pertinent in addressing the primary question:

1. What is technical data within the defense aerospace industry?

2. What are the functions that must be performed in order to produce technical data?

3. What are the cost elements involved in producing technical data?

4. What are the environmental factors that influence the cost elements of technical data?

5. What methods or techniques are used by the defense aerospace industry in estimating the cost elements of technical data?

C. SCOPE, LIMITATIONS, AND ASSUMPTIONS

1. Scope

This study was confined to the investigation of estimating methods utilized by the defense aerospace industry in the production of technical data. The subject of pricing technical data was not examined; rather emphasis was placed on estimating the costs of technical data production. No prior studies of technical data cost estimating methods could be found in searches of the literature base. Consequently, this researcher relied on personal interviews to obtain the majority of his data and information. The results of this research provide the reader with an overview of prevalent functions, cost elements, environmental factors and estimating

techniques utilized by the defense aerospace industry in the production of technical data.

2. Limitations

The number of defense aerospace contractors visited by this researcher was limited to five. Within those five, a total of twenty eight individuals in various departments were interviewed. It was felt that this number was sufficient to allow the researcher to establish a baseline of findings that apply to the aerospace industry as a whole. This study was further limited by the lack of prior research in the area of technical data cost estimation. This made it difficult for the researcher to develop starting points for data gathering that were common to the entire industry.

3. Assumptions

The presumption underlying this entire research effort is that defense aerospace contractors do have a method of estimating their cost of producing technical data. This study also assumes that the reader has a general knowledge of Department of Defense contracting language and the Defense acquisition process.

D. RESEARCH METHODOLOGY

The research methodology utilized in this study consisted of an examination of the literature base through the Defense Logistics Studies Information Exchange (DLSIE), the Defense Technical Information Center (DTIC), and review

of various journals and periodicals concerning the federal acquisition process. In addition, personal interviews were conducted with twenty eight employees of five major defense aerospace contractors. Individuals interviewed included program managers, contract managers, financial managers, and engineering/technical division managers. The interviews commenced with asking the subsidiary research questions. Follow-on questions were then posed based on responses to the initial questions.

E. ORGANIZATION OF THE REPORT

This report takes the reader through the subject in a logical manner. Chapter II presents such background information as the issues surrounding the ownership of technical data, the definition of technical data, the federal regulations concerning technical data, and some recent initiatives on technical data. It also covers generic cost estimating methods common to industry as a whole. Chapters III and IV summarize interviewee responses to the research questions and highlight conceptual differences between firms. Chapter V develops findings, conclusions and recommendations.

II. BACKGROUND AND THEORETICAL FRAMEWORK

A. INTRODUCTION

This chapter will examine the principal concerns of Government and industry regarding the development and use of technical data. It will discuss the issues of technical data from both the Government and the contractor viewpoint as outlined in recent publications. This chapter will also detail the basic concepts, regulations, and policies surrounding the issue of technical data and its cost. A definition will be discussed, and several regulatory requirements and initiatives will be presented. Finally, the most widely accepted, generic cost estimating techniques will be presented.

B. THE GOVERNMENT VIEWPOINT

Cost is not the sole criterion upon which to base a decision to buy technical data. Two recent Air Force surveys found that in addition to price, other factors to be considered include the life cycle cost of the system, the system's design complexity and stability, and its expected inventory in life [Refs. 1,2].

A major concern of the Government, however, is the cost of technical data. The decision to procure data should only be made after its cost is carefully weighed against the

life cycle cost of the equipment to which it pertains, and the savings expected to result from competition.

> If the purpose of reprocurement data is to achieve the advantages of competition and the resultant procurement dollar savings, then the cost of reprocurement data is a vital element in the determination of whether or not to buy reprocurement data. In other words, excess dollars spent for reprocurement data reduce or eliminate the savings from ownership of reprocurement data. [Ref. 3]

One of the principal reasons why the Government wants technical data is for the repair, training, and support functions that must be developed for any system that it purchases. Much of the equipment that the Defense Department procures is operated and maintained in remote areas, far from the manufacturer. An internal support system must be constructed for each item of equipment. Technical data is required from the supplier for the Government to develop and maintain this support system. The functions within this support system include personnel training, equipment maintenance and overhaul, spare parts cataloging, inspection and quality control, and packaging and logistics support. Without technical data, these functions cannot be fully developed and implemented.

Finally, the most controversial reason why the Government desires technical data is for competitive procurement. While most of the Government's requirements can be met by accepting data with restrictions, it is when data must be obtained for competition that the debate arises.

> ...the Government must make technical data widely available in the form of contract specifications in order to obtain competition among its suppliers, and thus further economy in Government procurement. [Ref. 4]

The Government's desire to achieve economy through competition is in direct contrast with industry's desire to retain a competitive edge.

C. THE INDUSTRY VIEWPOINT

The principal reason why industry retains technical data is to maintain a competitive edge over competitors. If providing technical data to the Government could possibly eliminate that edge, industry will, quite naturally, be reluctant.

> Commercial organizations have a valid economic interest in technical data pertaining to items, components, or processes which they have developed at their own expense. Such technical data is often closely held because its disclosure to competitors could jeopardize the competitive advantage it was developed to provide. Public disclosure of such technical data can cause serious economic hardship to the originating company. [Ref. 4]

In some cases, the data could be critical to the continued existence of the firm. However a contractor's desire to protect technical data is only one of many internally competing interests. A company may be willing to deal with the Government over technical data if that firm sees the potential for profit from the sale of such data.

D. A BALANCE OF INTERESTS

The Department of Defense Federal Acquisition Regulations Supplement (DOD FAR Supplement) recommends that a balance

be struck between the interests of the Government and those of industry.

> It is apparent that there is no necessary correlation between the Government's need for technical data and its contractors' economic interest therein. However, in balancing the Government's requirements for technical data against the contractor's interest in protecting his technical data, it should be recognized that there may be a considerable identity of interest. This is particularly true in the case of innovative contractors who can best be encouraged to develop at private expense items of military usefulness where their rights in such items are scrupulously protected. [Ref. 4]

At times, it is in the best interests of both the Government and industry to protect technical data that is both innovative and militarily useful. Without this protection, industry would not be inclined to make technological breakthroughs. Additionally, the Government should restrict its procurement of technical data to that which is actually needed. This policy will ensure a continued flow of data from industry and also control the costs of data maintenance, storage and retrieval. When technical data is desired, the Government should weigh its cost against other factors, such as the item's life cycle cost, design complexity and stability, and its expected inventory life. By making this evaluation, the Government will only procure technical data when it makes good sense.

E. DEFINITION, REGULATIONS AND POLICIES

1. Department of Defense Federal Acquisition Regulations Supplement

Prior to any discussion, a definition of what technical data is, must be established. Since the Federal Acquisition Regulations (FAR) are silent on the matter, the Department of Defense Federal Acquisition Regulations Supplement (DOD FAR Supplement) must be utilized. DOD FAR Supplement provides the following definition of technical data:

> Technical Data means recorded information regardless of form or characteristic, of a scientific or technical nature. It may, for example, document research, experimental, developmental or engineering work; or be usable or used to define a design or process or to procure, produce, support, maintain, or operate materiel. The data may be graphic or pictorial delineations in media such as drawings or photographs; text in specifications or related performance or design type documents; or computer printouts. Examples of technical data include research and engineering data, engineering drawings and associated lists, specifications, standards, process sheets, manuals, technical reports, catalog item identifications and related information, and computer software documentation. Technical Data does not include computer software or financial, administrative, cost and pricing, and management data, or other information incidental to contract administration. [Ref. 4]

Although very fundamental, this definition establishes the idea that technical data is a broad concept that encompasses many different products. For the purposes of this study, the researcher has adopted the following definition of technical data: recorded information regardless of form or characteristic, of a scientific or technical nature.

The following are examples of various kinds of data: research and development data, design disclosure data, quality assurance data, installation and maintenance data, operating data, manufacturing data, and configuration management data. It is readily apparent that technical data consists of a broad spectrum of information in a diverse number of formats.

There are four possible data policies that may be pursued by the Government. They are: full data with unlimited rights, full data with limited rights, limited data with full rights and limited data with limited rights. A full data with unlimited rights policy requires the contractor to deliver, without restrictions, all data generated under the contract. This permits the Government to use the data for competitive reprocurement. A full data with limited rights policy allows the contractor to place restrictive markings on data considered proprietary. The Government can only use the restricted data for internal purposes. A limited data with full rights policy requires the contractor to deliver all unrestricted data, but he can withhold any that is proprietary. Lastly, a limited data with limited rights policy requires that any data delivered to the Government be free of restrictions. Any proprietary information is allowed to be withheld by the contractor. However, if the contractor is ordered to deliver the restricted data, it is understood that the Government will accept it with restrictive markings. In the past, the basic policy of the

Government has been to obtain full data with limited rights [Ref. 5]. With the current emphasis on obtaining competition, however, the Government is turning more toward the acquisition of full data with unlimited rights.

2. Department of Defense Instruction 5010.12

This instruction provides the same basic definition of Technical Data as found in DOD FAR Supplement, but goes on to add that the first step in establishing the data requirement is a Determination of Intended Use:

> Personnel representing program management, engineering, procurement, training, maintenance, operations, logistics support and other functional areas will determine the content and intended use of technical data in consonance with the responsibilities assigned to the Program or Project Managers and the needs of the specific project.
>
> Consideration shall be given to materiel readiness and operational planning factors which led to generating the requirements for a specific system, end item, equipment, material or service to which the required data relates. [Ref. 6]

Program personnel review each aspect of the system to be developed and attempt to determine the level of data required. The instruction also provides different factors to consider when making the determination. They include such things as whether the item is for a single installation with no additional procurement anticipated, whether the item is "one-of-a-kind" with no planned production, or whether it could progress from development all the way to final production, and whether it is a "breakout" candidate. This procedure is becoming more critical in light of recent initiatives

to obtain data from contractors for the purpose of competitive reprocurement.

3. Contract Data Requirements List (DD Form 1423)

The Defense Aerospace Contractors interviewed by this researcher frequently mentioned the Contract Data Requirements List (CDRL) when discussing technical data. A presentation of the CDRL is necessary here since it will be referred to repeatedly in subsequent chapters. The CDRL is used by the Government to delineate all deliverable data requirements. Its use is required by DODI 5010.12. The pricing of each line item on the CDRL provides the Government with a means of weighting the cost of the data against its perceived worth. The price of the data should be based on the "over and above" concept; that is, it should be based on what it cost the contractor to produce the item for the Government, over and above what it would have cost if the item were produced solely for the contractor's internal use [Ref. 7]. Four price groups are recognized in the application of the "over and above" concept. They are:

Group I--Data prepared solely for the Government's use, that the contractor would otherwise not have prepared.

Group II--Data necessary for contract performance that must be modified to meet the requirements of the Government.

Group III--Data the contractor develops for his own use which needs no modification prior to submission to the Government.

Group IV--Data developed by the contractor for use in the commercial arena.

4. Recent Initiatives

The issue of technical data has arisen frequently in the recent past. The forum in which it has been raised gives an indication of the level of interest technical data has reached within Government. The following are some of the more recent legislative proposals and regulatory guidances that have been issued.

The 1984 Department of Defense Authorization Act contained a provision that prevented the obligation or expenditure of any funds for a certain laser guided projectile until:

> ...the Secretary of the Navy has acquired a technical data package for that projectile and has determined that such technical data package (1) does not contain proprietary data, and (2) can be used to solicit a second production source for such projectile. [Ref. 8]

In February 1984, H.R. 4842 was introduced in the House of Representatives. This bill would have required a paragraph in procurement contracts specifying a time limit after which the contractor would:

> ...grant the agency rights to the use of any technical data...pertaining to parts and components to be delivered to the United States under the contract that are subject to replacement. The technical data... covered shall provide adequate, complete, and usable information so as to allow subsequent competitive procurement of such parts or components from another competent manufacturer. [Ref. 9]

Under this bill, the maximum time for the transfer to occur would be seven years.

Although H.R. 4842 was rejected in conference committee, the Department of Defense Authorization Act for

fiscal year 1985 contains a provision that allows the Secretary of Defense to establish a contractual time limit of not more than seven years for the transfer of technical data to the Government.

In May 1984, the Chief of Naval Material issued a memorandum as an advance change to the Navy Acquisition Regulation Supplement. It created a clause entitled "Acquisition of Unlimited Rights in Technical Data and Computer Software." A portion of that clause states:

> ...the Contractor agrees to submit a firm fixed price proposal for each item listed in Attachment 1 and to enter into good faith negotiations to establish prices. In the event of failure to agree on a price, the PCO may, with the approval of the Head of the Contracting activity, determine a reasonable price, subject to appeal by the Contractor in accordance with the "Disputes" clause of this contract. [Ref. 10]

The "Attachment 1" referred to in the text is a list of data items which the contractor intends to deliver with limited rights. This memorandum clearly demonstrates that the Navy intends to aggressively pursue the procurement of technical data. Defense contractors are on notice that they will provide it.

F. GENERIC COST ESTIMATING METHODS

In subsequent chapters, reference will be made to cost estimating methods utilized by Defense Aerospace Contractors. In order to familiarize the reader with these estimating techniques, the three "major methods" as described by C.A. Batchelder will be discussed [Ref. 11].

1. Parametric

The first and most prevalent means of cost estimating is the parametric method. It employs known estimating relationships between variables such as weight, speed, power or thrust, and cost, as expressed in dollars. Frequently referred to as Cost Estimating Relationships, or CERs, these known relationships are then applied to the parameters of the new system to develop a cost estimate [Ref. 11]. For example, in the area of airframe manufacture, known cost estimating relationships exist in terms of dollars per pound of weight, per pound of thrust, and so forth. These relationships are used with the variables of a new airframe to develop its estimated cost.

2. Analog

The analog method of estimation is based on a comparison of the new system with a prior one. Although the two are not identical, an estimate is made by considering their likenesses and differences in design and performance [Ref. 11]. For example:

> The use of new structural material for aircraft often requires the development of special cutting and forming techniques with manufacturing labor requirements that differ significantly from those based on a sample of primarily aluminum airframes. Faced with this problem when titanium was first considered for use in airframe manufacture, airframe companies developed standard-hour values for titanium fabrication on the basis of shop experience in fabricating test parts and sections. [Ref. 11]

In this instance, the experience obtained while fabricating test parts and sections was considered analogous to the effort necessary to build the entire airframe.

3. Engineering

The final method is called the engineering method. It involves breaking down the system into separate segments of work. These segments are then examined at a low level of detail and estimates are made for each. The detail estimates are then consolidated into a total estimate for the overall system [Ref. 11]. This method is normally used when a thorough, detailed analysis is required for all the processes involved. When defense aerospace contractors employ the engineering method of cost estimating, they frequently use a Work Breakdown Structure (WBS) to develop it. The WBS is defined in Military Standard 881A as:

> ...a produce-oriented family tree composed of hardware, services and data which result from project engineering efforts during the development and production of a defense materiel item, and which completely defines the project/program. A WBS displays and defines the product(s) to be developed or produced and relates the elements of work to be accomplished to each other and to the end product. [Ref. 12]

The WBS is organized in levels, each of which is comprised of a number of elements. A cost is estimated for each component element and totaled at each level. An overall estimate consists of the total of all the levels.

G. SUMMARY

This chapter outlined the concerns regarding the development and use of technical data. The issues from both the Government and industrial viewpoint were discussed. The concept of striking a balance between Government and

industry requirements was presented. A definition of technical data was established, and the different regulations, laws and policies surrounding the subject were reviewed. Finally, a description of the most prevalent cost estimating methods was presented.

III. DEFINITIONS, FUNCTIONS, COST ELEMENTS, AND ENVIRONMENTAL FACTORS

A. INTRODUCTION

This chapter will present contractor responses to the first four research questions. The following chapter will detail their answers to the final research question. Twenty eight individuals within five major defense aerospace firms were interviewed. To encourage a frank and open exchange, this researcher promised that all statements would be non-attributable. Therefore, nothing in this study has been ascribed to any particular individual or company. Different responses to the same questions are combined to form aggregate observations.

B. DEFINITION OF TECHNICAL DATA

Research question: What is technical data within the defense aerospace industry?

A multitude of interpretations were provided as definitions of technical data. The responses, however, can be segregated into two general types. The first comprises a large list of specific items considered by the contractors to be elements of technical data. Among the most common items identified were: drawings of all kinds (such as engineering, interface, process, and assembly drawings), computer software, design information specifications, process specifications, configuration management data,

provisioning technical documentation, technical manuals, and test documentation. The list also includes customer required reports such as performance reports, analysis reports, "-ility" reports (reliability, maintainability, survivability, etc.), safety reports, technical reports, and progress and financial reports. All of these are considered by the contractors to be technical data. The reason for this becomes apparent when the second type of response is examined.

The second type of response to the technical data definition question was an assemblage of broad interpretations. They include such ideas as: "anything not hardware," "anything that has to do with the end item product," "anything that does not comprise administrative data," and "everything that has a deliverable requirement."

The most common, broad-based definition of technical data that consistently recurred throughout the interviews was "all requirements outlined in the Contract Data Requirements List (CDRL)." As mentioned earlier, since the CDRL is used by the Government to indicate reporting requirements as well as data requirements, the contractors consider these reports to be technical data. But all the reports do not meet the Government's definition of technical data in that some of them, such as progress and financial reports, are completely non-technical in nature. So a dichotomy exists between the Government's definition of technical data, as outlined in DOD FAR Supplement, and industry's perception

of what constitutes technical data (as required in the CDRL).

C. TYPICAL FUNCTIONS

Research question: What are the functions that must be performed in order to produce technical data?

It is this researcher's opinion that the creation of technical data can be broken down into four distinct phases: generation, capture, documentation and delivery. The generation phase involves data creation. It is an abstract process which is comprised of the formation of mental concepts. In the capture phase, these mental concepts are recorded in rough format on an informal medium such as an engineer's notebook. The documentation phase involves the structuring of that data into words and drawings. In the delivery phase, the technical data is provided to the customer via the medium requested; such as magnetic tape, manuals, or microfilm.

The functions performed during technical data production that were most frequently identified by the interviewees are analysis, design, recording, and handling. The analysis function consists of examining the performance and other parameters of the proposed system. A determination is then made as to what configurations are necessary to meet those parameters. During the design function, the data that will incorporate the configurations is planned and outlined. The recording function, which occurs in conjunction with design,

involves placing the data onto a medium such as drawings and text. Finally, the data is assembled, copied, and distributed in the form requested by the customer during the handling function.

Within these four functions, the components of work identified by interviewees were the same. Those most often mentioned included drawing, drafting, composing, word processing, reproduction, printing, and reformatting. One interviewee expanded his interpretation of the functions performed in the production of technical data. He stated that depending on the particular function that was in effect, the components of work internal to that function would vary in intensity. For example, the early life of a project consists mainly of the analysis function. During that analysis, the majority of the costs incurred stem from drawing and drafting, with very little printing or reformatting. Looking at all five contractors, there were no significant differences in functions performed or components of work within those functions. These are the four phases and the functions performed on technical data as it evolves. It should be noted that during the life of a program, this process repeats itself whenever configuration changes are made to the system. The technical data are reprocessed through each phase and every function is performed again in order to reflect the changes.

D. TYPICAL COST ELEMENTS

<u>Research question</u>: What are the cost elements involved in producing technical data?

The question of cost elements involved in producing technical data revealed two distinct areas. The first consists of the cost elements incurred during data production. The second area is comprised of cost drivers that influence the extent to which each cost element is incurred.

Interviewees indicated that labor is the first major cost element incurred in the data production process. Expressed in manhours, it includes engineering labor of all types, supervision, management, quality assurance, planning, coordination with the project office and customer, performance tracking, data base initiation and maintenance, vendor data acquisition, drawing maintenance, provisioning conferences, software maintenance, clerical support, editing, typing, printing and reproduction. Interviewees further stated that labor comprises eighty to ninety percent of the total cost incurred in technical data production.

The second cost element is computer time, expressed in hours. Although Computer Aided Design (CAD) is still in the development stage, it is widely used in the production of elementary designs. Many of those interviewed felt that CAD will become an increasingly prominent cost element as it becomes capable of handling more complex and intricate design functions.

The third and final cost element is material. The majority of material expenses consist of paper and other office supplies, as well as reproduction and printing consumables. The amount of material used in the production of technical data is largely a function of the frequency and quantity of data and report submissions required by the CDRL.

Cost drivers affect the degree to which each cost element is incurred. Technical complexity and performance requirements are both strong cost drivers. A high speed, multi-mission fighter-bomber, for example, has more electronic interface requirements, is more technically complex, and has higher performance requirements than those of a trainer aircraft. Technical complexity and high performance requirements result in the creation of a large quantity of technical data to support that system. Another strong cost driver is the amount of computer software required for a system. The number and complexity of programs needed to run the various computers on an aircraft adds directly to the amount of technical data needed to support that aircraft. A final cost driver is new requirements or changes that are enacted after commencement of system development. This is the strongest cost driver of all because it involves the costly and time-consuming process of redesign. Interviewees said that it is difficult to accurately estimate the cost of a redesign effort. They stated that normally they resort to an

audit of the entire data package for each design change in order to determine the number of drawings and pages of data that are affected. An estimate is then made of the manhours and other cost elements necessary to implement that change. Figure 1 illustrates the effect cost drivers have on the cost elements.

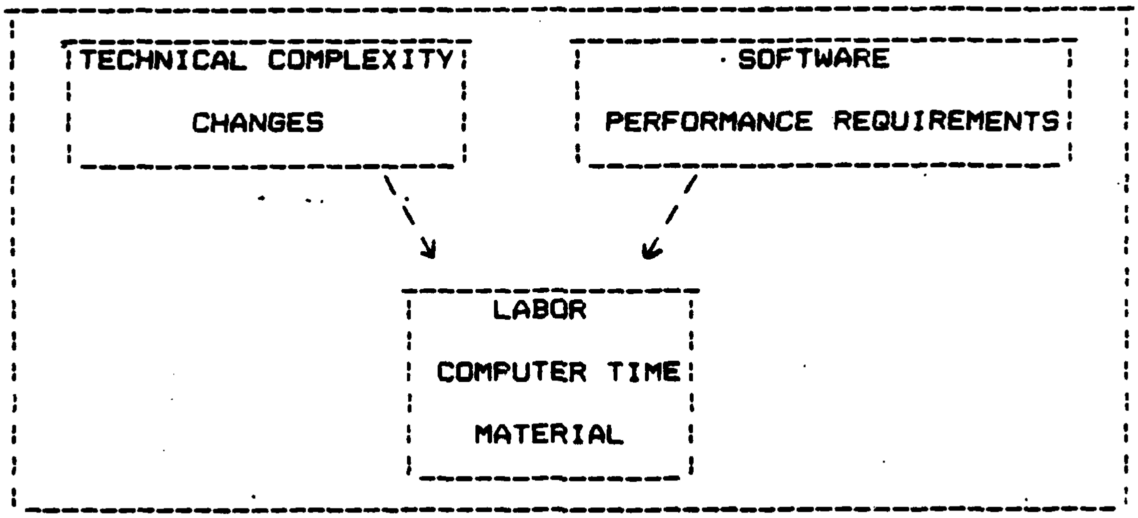

Figure 1. Effect of Cost Drivers on Cost Elements

In comparing all five contractors, differences in cost elements identified were based on the relative position of the interviewee in his organization. Those in supervisory positions tended to interpret cost elements as specific items that could be identified to a particular job, such as drafting or reproduction. Whereas individuals in managerial positions thought of cost elements in much broader terms

such as preparation, administration, and release. Between all five firms, however, the major cost elements of labor, computer time, and material remained the same.

E. ENVIRONMENTAL FACTORS

Research question: What are the environmental factors that influence the cost elements of technical data?

A large number of responses were received about environmental factors that influence data cost elements. From these, the researcher combined a number of similar ones, and outlined the most frequent and influential ones. For the purposes of this study, environmental factors are defined as those things that can influence the level of cost elements incurred, but are not directly controlled by the contractor nor included in his initial cost estimate.

The majority of environmental factors mentioned are directly related to the CDRL. One factor frequently mentioned was ambiguous CDRL requirements. The ambiguity results when it is not clear what a certain report is supposed to contain, or when the costs incurred while gathering information for a report would exceed the worth of that information. Interviewees indicated that the issue is negotiated to produce a less costly item, yet something that still meets the needs of the customer.

A second CDRL item mentioned by interviewees was premature requirements. Contractors are sometimes required to

submit drawings and reports to the Government before the design is fully stabilized. This results in multiple review and comment cycles which, in the interviewees' opinion, causes the system design to remain unstable for a much longer period of time.

Another problem cited by an interviewee was that CDRL requirements do not keep pace with advances in technology. This results in requirements that can no longer be met, as the system design has been changed to incorporate the new technology. Since the CDRL requirement is still structured around the previous design, the contractor must negotiate with the customer to develop ones that are tailored to the new design. Interviewees stated that in many cases, this causes them to incur additional expenses that elevate their original cost estimate.

Changes to technical data were mentioned previously as a cost driver. One interviewee considered the quantity of changes to be an environmental factor because many of them are customer driven. He estimated that the audit resulting from each change usually increases the cost of the original data package by sixty to seventy percent.

When speaking of environmental factors, all those interviewed had a perspective that encompassed only customer actions that influence the production cost of technical data. Only one person admitted to another influence; that of other governmental (state and local) laws and regulations. None

of the interviewees considered their firm's internal actions as environmental factors.

F. ANALYSIS

Studies found in the literature base by this researcher are principally concerned with the Government's desire for technical data transfer, and the reluctance of contractors to allow it. These issues were presented in Chapter II. No studies were found that explore the underlying concepts of what the functions are that produce technical data, what their cost elements are, and what influences those elements. The interviews conducted by this researcher indicate that defense aerospace contractors are fully aware of these issues. As the Government requires more technical data transfer in the interest of competition, it is the opinion of this researcher that Government analysts will want to know more about data production functions and their associated costs. The interview results presented in this chapter are a first look at these concepts. More studies and analyses are needed in order to expand the information base in this area.

G. SUMMARY

This chapter presented findings to the first four research questions. It examined how aerospace contractors defined technical data and identified the typical functions performed in data production. The cost elements involved

were then separated into elements and drivers. Finally, various environmental factors that influence the cost elements were identified.

IV. COST ESTIMATING METHODS

A. INTRODUCTION

This chapter will discuss the cost estimating methods common to the defense aerospace industry in the production of technical data. Each type of estimating method is presented with statem nts regarding its relative importance. Finally, an analysis of these methods is presented, with a discussion of the rationale for their use.

B. PRACTICAL ESTIMATING METHODS

1. Analog

The most prevalent technique of cost estimating the production of technical data within the defense aerospace industry is the analog method. The data to be produced is first compared with a recent project to determine if there are any common elements. If it is found that a significant portion of the new system is similar to a former one, then the hours of effort and material expended to produce the previous data are used as a base estimate. Differences in the design and performance of the two systems are then considered. Estimates are made for these and added to the base. Interviewees stated that the analog method was their preferred technique simply because it is the quickest and simplest. They said that their normal mode of operating includes budget

and time constraints. In their opinion, analog estimating provides them sufficient accuracy for the least cost in the shortest time.

2. Engineering

When the data to be developed cannot be fitted to an analogy, interviewees indicated that they utilize the engineering method of estimating. There are two prevalent situations for using this method. The first is when the data to be produced is for an entirely new system. The second is when the contractor is new to the business and has no cost data base with which to develop an analog estimate. Interviewees stated that the Work Breakdown Structure is frequently used to reduce the system to its lowest elements. Bottom up estimates are then made within each department that participates in data development. These estimates are then aggregated into a total for the entire technical data package. Interviewees stated that this method is more expensive than the analog method because it requires more time and personnel. Each department that participates in the production effort must formulate a cost estimate on the elements it works on. A large amount of managerial effort is also necessary to coordinate the entire estimating process.

3. Parametric

This researcher found that parametric estimating of technical data production costs is the method least employed among defense aerospace contractors. The consensus of those

interviewed was that parametric cost estimates do not provide enough accuracy for internal budget control. Constant changes in technology invalidate cost estimating relationships faster than new ones can be developed. Only the technical manual departments of the contractors visited consistently relied on parametric estimating methods. For any type of manual (maintenance, training, etc.), department managers have determined from personal experience that historical costs are consistent enough to permit parametric estimating. One contractor, for example, has a classification system comprised of three different levels of technical data: "new, revised," and "lift." Each classification has a predetermined rate for every cost element utilized in the technical manual production process. The "new" classification is used for "first time" data development. It contains the highest rates for cost elements. The "revised" classification contains a lower level, because much of it is derived from previous projects. The "lift" classification has the lowest cost rates, as it is taken from a prior system and is comprised entirely of reproduction effort.

C. ANALYSIS

Interviewees stated that their preference for any one of the three estimating methods (analog, engineering, or parametric) is based on a number of considerations. The first is whether the contractor has an existing experience base from which to draw an analogy to the new system. If he

does, then the analog method is employed. If he does not, then the manager considers what other estimating method will provide accuracy yet be expedient and relatively inexpensive. For technical data production, interviewees stated that, from their experience, the engineering method was their next choice; simply because it provided more accurate cost estimates than parametric methods. Interviewees admitted that the engineering method was more time consuming and expensive than parametric estimating. However, in their opinion, the accuracy of an engineering estimate consistently exceeded that of a parametric estimate.

Only one contractor used the engineering method as a primary estimating technique. The reason for this was that the firm was relatively new to Government contracting, and did not have a historical cost data base upon which to make analogous estimates. Personnel interviewed pointed out that they were aware of this fact and planned to employ analog estimating as soon as practical.

D. SUMMARY

This chapter discussed the cost estimating methods prevalent in the defense aerospace industry for the production of technical data. Each method was presented with reasons for its employment. Finally, an analysis was made of the decision process defense aerospace contractors employ in deciding which estimating method to use.

V. PRINCIPAL FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

A. PRINCIPAL FINDINGS AND CONCLUSIONS

The objective of this study was to determine what cost estimating methods are utilized by defense aerospace contractors in the production of technical data. The principal findings and conclusions are derived from opinions received in personal interviews.

1. A dichotomy exists between the Government's definition of technical data as outlined in DOD FAR Supplement, and industry's perception of what constitutes technical data (as required in the CDRL). Defense aerospace contractors are driven by CDRL requirements. They consider anything that is listed in the CDRL to be technical data. This perception contrasts with the DOD FAR Supplement definition of technical data.

2. The cost of producing technical data has two distinct areas: cost elements and cost drivers. Cost elements are specific types of expense, such as labor, computer time and material. Cost drivers influence the degree to which each expense type is incurred. They include such things as technical complexity and performance requirements.

3. The majority of defense aerospace contractors interviewed feel that environmental factors (that influence the cost elements of technical data production) come solely

from the customer. Most of the environmental factors mentioned were directly related to the CDRL.

4. The analog method is the first choice of defense aerospace contractors in estimating the cost of technical data production. This is the preferred method simply because it is quick and simple, yet provides accuracy.

5. The engineering method is the second choice of defense aerospace contractors in estimating the cost of technical data production. Admittedly more expensive, this method is employed for its accuracy when analog methods cannot be used.

6. Parametric estimating is only used for technical manual production and as a "reasonableness check" for estimates developed by analog or engineering methods. Cost estimating relationships are continuously invalidated as advances in technology are made. They do not provide enough accuracy for internal budgeting purposes.

B. RECOMMENDATIONS

1. CDRL requirements should be clearly delineated in order to reduce ambiguity and misunderstandings. Currently, CDRL requirements are not clearly understood. This results in delays and misunderstandings on the part of the contractor.

2. The Government should divorce non-technical reporting requirements from the CDRL, or modify its definition of technical data to include non-technical items. Defense aerospace contractors consider anything that appears on the

CDRL as technical data. Yet the CDRL is used by the Government to require many non-technical reports. This disparity should be cleared up by segregating the non-technical requirements, or by modifying the DOD FAR Supplement definition of technical data.

C. RECOMMENDATIONS FOR FURTHER RESEARCH

There is general agreement among the defense aerospace contractors interviewed that a relationship exists between the cost elements, cost drivers and environmental factors of technical data production. However, there is no prior research that substantiates this claim. It is therefore recommended that a study be conducted of these cost elements, cost drivers, and environmental factors. The focus of this study should be to quantify the relationships between them and determine the degree of sensitivity each cost element has with respect to each cost driver and environmental factor. Once the relationships and sensitivities are established, a range of probabilistic variances can be determined by reviewing historical cost data. The following matrix illustrates the relationship.

D. ANSWERS TO RESEARCH QUESTIONS

As a summary of the information presented, the following is a restatement of the primary and subsidiary research questions and their answers.

COST ELEMENTS DRIVERS AND FACTORS	LABOR	COMPUTER TIME	MATERIAL
TECHNICAL COMPLEXITY			
PERFORMANCE REQUIREMENTS			
COMPUTER SOFTWARE			
NEW REQUIREMENTS AND CHANGES			
CDRL AMBIGUITY			
PREMATURE REQUIREMENTS			
REQUIREMENTS LAG TECHNOLOGY			

Figure 2. Matrix of Cost Elements, Cost Drivers, and Environmental Factors

Primary research question

Question: What methods are used by the defense aerospace industry to estimate the cost of technical data?

Answer: In order of preference, the five defense aerospace contractors interviewed utilize analog methods, engineering methods, and parametric methods (for technical manuals and as "reasonableness checks").

Subsidiary research questions

Question: What is technical data within the defense aerospace industry?

Answer: Based on responses from those interviewed, the prevalent definition of technical data is all requirements outlined on the CDRL.

Question: What are the functions that must be performed in order to produce technical data?

Answer: The four functions performed to produce technical data are analysis, design, recording and handling.

Question: What are the cost elements involved in producing technical data?

Answer: The prevalent cost types are labor, computer time and materials. These are influenced by cost drivers such as technical complexity, performance requirements, software requirements and changes/new requirements.

Question: What are the environmental factors that influence the cost elements of technical data?

Answer: From the perspective of defense aerospace contractors, the majority of environmental factors are directly related to the CDRL. They include ambiguous requirements, premature requirements, and requirements that lag behind technology.

Question: What methods or techniques are used by the defense aerospace industry in estimating the cost elements of technical data?

Answer: In order of preference, the estimating methods utilized within the defense aerospace industry are analog methods and engineering methods. Parametric methods are only used to estimate technical manual cost elements and as "reasonableness checks" for analog or engineering estimates.

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